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Administrative
Services Division

December 21, 1981

Laboratory Chemical Fume Hoods — Standards

MANUAL 232.1

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ORIGINATING OFFICE:	SUBJECT:
Administrative Services Division Safety and Health Program Management Branch	Laboratory Chemical Fume Hoods - Standards
DISTRIBUTION: Headquarters, Regions, Areas/Centers, and Locations	

A REFERENCE

For policy and responsibilities, see DIRECTIVE 232.1.

B SUMMARY

This MANUAL contains detailed standards and information for:

1 Laboratory fume hood containment.

2 Types of Chemical Fume Hoods.

3 The aerodynamics of laboratory fume hood containment.

4 Design features of laboratory fume hoods.

5 Hood exhaust systems.

6 Exhibits which include:

- Laboratory Chemical Fume Hood Specifications and Performance Tests
- Corrosion Resistance Chart
- Diagram of Acceptable Stack Head Designs

C FORM

S&E-283, Laboratory Chemical Fume Hood Inspection (for local reproduction)

D DEFINITIONS

1 <u>Air Vector</u> - The direction of air flow.

2 <u>Back Baffle</u> - A rear partition which usually has two adjustable slots and one fixed slot.

3 <u>Bypass</u> - The opening which allows air to enter the hood when the sash is closed.

D DEFINITIONS (Continued)

4 Face Opening of Hood - The opening bounded by the two side airfoils, countertop, and the bottom of the sash (when measurements are taken).

5 Face Velocity - The velocity of air (in feet per minute-fpm) passing through the face of the hood.

6 Plenum - A pressure equalizing chamber.

7 Pulsing - Frequent movement of air in different directions; as opposed to a steady state or linear flow condition.

8 Rolling Effect - The movement of air in the top section of the hood which rolls around above the bottom of the sash when the sash is in a raised position.

9 Short Term Exposure Limit (STEL) - The maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from (1) irritation; (2) chronic or irreversible tissue change; or (3) narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the TLV-TWA also is not exceeded. The STEL should be considered a maximal allowable concentration, or ceiling, not to be exceeded at any time during the 15 minute excursion period.

10 Threshold Limit Value - Time Weighted Average (TLV-TWA) - The time-weighted average concentration for a normal 8-hour workday and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

11 Threshold Limit Value-Ceiling (TLV-C) - The concentration that should not be exceeded even instantaneously.

12 Uranine - Sodium fluorescein.

F GUIDELINES

1 Laboratory Fume Hood Containment - General.

a The purpose of a laboratory fume hood is to prevent or minimize the escape of contaminants into the laboratory. This is accomplished by drawing air from the laboratory, past the operator, into the hood. The concentration of the contaminant in the actual breathing zone of the operator must be kept as low as possible and must never exceed the applicable TLV-TWA for the materials in question. Since the laboratory worker is seldom stationed at the hood for long periods of time (periods approaching 8-hours duration),

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F GUIDELINES (Continued)

the STEL, the TLV-C, or the peak value as proposed in the ACGIH listing of TLV's shall be used whenever possible in assessing permissible worker exposure levels. Where no STEL or TLV-C has been proposed, the ACGIH suggested excursion factor shall be applied to the TLV proposed as a time weighted average. The use of TLV's alone to decide the type of hood and the air velocities required for control is discouraged. For materials of unknown toxicity or where specific toxicity data is not available, a system based on the ratio of the compound vapor pressure/"assumed TLV" selected on the basis of the TLV for a similar compound is the method of choice for providing the best indication of the potential hazard.

NOTE: "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes" is a handbook published by the ACGIH. It is available for purchase at a price of $2.50 from:

American Conference of Governmental
Industrial Hygienists, Inc.
P.O. Box 1937
Cincinnati, Ohio 45201
Phone: (513) 825-0312

b In every event, it is the actual exposure outside of the hood that is the critical factor. Assistance for the determination of the above parameters is available through:

Safety and Health Program Management Branch
Administrative Services Division, S&E
Room 529A, Federal Building
6505 Belcrest Road
Hyattsville, Maryland 20782
ATTN: Industrial Hygienist
Phone: FTS: 436-6475
Comm: (301) 436-6475

c The ability of a laboratory hood to provide adequate protection for the user, within the exposure limits noted above, depends on many factors. Prime concerns include:

(1) Air movement and flow patterns in the room.

(2) Turbulence within the hood work space.

(3) The effect of the operator on the air flow pattern at the hood face.

(4) The control velocity at the hood face.

F GUIDELINES (Continued)

These factors must be considered as a group if the hazard control performance of the hood is to be effectively determined.

2 Types of Chemical Fume Hoods.

The following types of chemical fume hoods are presented for informational purposes with minimal comment as to specific advantages, disadvantages, or performance characteristics. Any hood design encountered may be the result of a combination of the following types.

a "Standard" or "Conventional" Hood.

This hood consists of an enclosure having three sides and a vertically sliding sash in front. It is equipped with a rear panel or baffle for the adjustment of air flow. The exhaust duct is connected to an exhaust plenum located between the baffle and the back wall of the hood. The fan draws 100 percent room air through the sash opening, through the baffle slots, plenum, and ductwork to the outside atmosphere. As the sash is lowered from the fully opened positio the face velocity increases in an approxmate inverse proportion to the face area. A variation of the standard hood attempts to conserve room air during lowered sash operation. A two-speed fan, operated by a microswitch, tripped when the sash is lowered to within a certain level above the work surface, cuts back to reduce the amount of room air exhauste and achieves a more constant face velocity over the range of sash positions. This approach is acceptable as long as minimum capture, slot, and transport velocities are maintained.

b "Balanced Air" or "Bypass" Hood.

The high face velocity air stream created when the standard hood sash is lowered may cause problems such as excessive turbulence or disruption of operations within the hood. These problems may be overcome by the provision of an inlet for room air to be drawn through a bypass directly into the hood as the sash lowered. With the sash fully open, the bypass is closed and inoperative. The quantity of air admitted to the hood through the bypass increases as the sash is lowered, but the combined volume through it and the face opening of the hood remain constant. The face velocity and the quantity of air exhausted from the laboratory are relatively constant, thus avoiding variable loads on ventilation or air conditioning systems.

F GUIDELINES (Continued)

c <u>"Auxiliary Air" or "Supplied Air" Hoods</u>

Air conditioning of laboratory buildings and rooms requires refrigerating capacity not only to compensate for heat gain through the walls of the building and the heat load generated in laboratory processes, but also sufficient for a flow of supply air equivalent to that exhausted by all hoods in the space. Correlations between fume hood exhaust and air conditioning refrigeration have been made. Each 1,000 CFM exhausted equals approximately 3-5 tons of refrigeration system capacity. For this reason, auxiliary supply hoods have been designed to supply outside unconditioned air as a percentage of the air exhausted by the hood. While twice as much hood ductwork is required, the additional cost may be offset by the energy savings. These comparative savings continue to accrue as energy costs increase. <u>In no instance, however, is there justification to compromise the hood performance or the intrinsic safety of a system in the name of energy efficiency</u>.

The following sections discuss two concepts of auxiliary air-supplied hoods.

d <u>"Internally Supplied" Auxiliary Supply Hoods</u>.

The internally supplied hood supplies outside unconditioned air behind the sash, directly into the hood interior. The face velocity through the face opening of the hood is thus drastically reduced, and the hood cannot prevent leakage or outfall of contaminants into the room. Internally supplied hoods do not save any room air, they merely increase the capacity requirements of the exhaust system in order to maintain adequate face velocity and contaminant control. Reductions in face velocity may result from a number of factors, such as building system imbalance, hood supply and exhaust imbalance with increased percentage of supplied air, or as a result of improper original installation.

For these reasons, auxiliary air should never be introduced directly into the hood. <u>These systems may, in fact, be worse than useless</u>.

e <u>"Externally Supplied" Auxiliary Air Hoods</u>.

Systems supplying air to the outside of a hood have a theoretical superiority. This superiority is, however, conditional upon the following requirements:

F GUIDELINES (Continued)

(1) All or most of the supplied air must reach the hood face.

(2) Adequate uniform face velocity must be maintained.

(3) No excessive turbulence can be tolerated at the hood face or hood interior.

Designs that do not meet these requirements must be avoided.

Generally, the most effective system available provides a horizontal supply located above the face of the hood which directs air downward at a moderate velocity until it is captured in the air stream entering the hood face. Test methods that involve the introduction of a known amount of tracer into the supply stream and measurement of the concentration in the hood exhaust are available. Details of these methods are contained in Exhibit 1.

Auxiliary air hoods must be provided with a bypass to direct the supplied air into the hood when the sash is closed to facilitate the air conditioning system balance and control the face velocity increases as the sash is lowered.

f <u>Perchloric Acid Hood</u>.

The perchloric acid hood is a special adaptation of the standard or the auxiliary air hood for particular use with perchloric acid or other dangerous oxidizers. These hoods are equipped with water or steam sprays along the entire length of the exhaust duct and in the space between the baffle and the back wall of the hood. The sprays are operated periodically or after each use to wash down acid crystals and organic materials that may have accumulated. Receiving drains are built into the hood for the wash water. The inside surface of the hood is usually hosed down or washed by hand.

Due to the extremely hazardous and explosive nature of perchloric acid in combination with organic matter, the ACGIH lists the following recommendations for perchloric acid hoods:

(1) Do not use any other material, especially organic materials, in a hood designed specifically for perchloric acid. Do not use perchloric acid in a hood designed for other purposes. Identify perchloric acid hoods with large warning signs.

(2) Locate all utility controls on the outside of the hood.

F GUIDELINES (Continued)

(3) Materials of construction for this type of hood and ductwork must be nonreactive, acid resistant, and relatively inpervious. Stainless steel, type 316 with welded joints, is preferred. Unplasticized polyvinyl chloride or an inorganic ceramic coating such as porcelain are acceptable.

(4) Ease of cleanliness is paramount. Use all-welded construction or impermeable inorganic sealants for joints with accessible rounded corners.

(5) The work surface should be water tight with a minimum of 1/2 inch dished front and sides, and an integral trough at the rear to collect the wash-down water.

(6) Design wash-down facilities into the hood and ductwork. Use daily or following each use to thoroughly clean perchloric acid from the exhaust system surfaces.

(7) Each perchloric acid hood must have an individual exhaust system. Avoid horizontal runs and sharp turns in the ductwork.

(8) Construct the hood and ductwork to allow for easy visual inspection of hidden surfaces.

(9) Consider the use of a high efficiency (greater than 80 percent) wet collector constructed for perchloric acid service. Locate as close to the hood as possible to minimize the accumulation of perchloric acid in the exhaust duct.

(10) Use only an acid resistant metallic fan, a metallic fan protected by an inorganic coating, or an air ejector.

(11) Lubricate the fan with a fluorocarbon type grease.

(12) Locate the fan outside of the building.

(13) Use the stackhead design designated in Exhibit 3 of this MANUAL.

g Radioactive Hoods.

Hoods for radioactive materials are usually variations of standard or auxiliary hoods specially constructed to permit easy cleaning. They are usually equipped with High Efficiency Particulate Air (HEPA) filters in the exhaust ductwork on top of the hood to collect radioactive particulate matter.

F GUIDELINES (Continued)

Glove boxes with disposable charcoal filter cartridges are also available from commercial sources. The HEPA filters and the cartridges must be disposed of properly with other secured radioactive wastes generated by the facility.

3 Laboratory Fume Hood Containment - Aerodynamics.

a Required Face Velocities.

Face velocities of 80-100 fpm will provide adequate containment of laboratory contaminants, if the overall installation can be rated as "good" in reference to the other listed performance factors (see b and c below). Control velocities must overcome the particle kinetics of aerosols, the molecular diffusion of gases and vapors, and all other "normal" activities which take place inside and outside of the hood. The vector of the air at the face of the hood must be inward and perpendicular to the face. Flows lower than 80 fpm do not provide the safety factors desired for normal conditions such as operator movements. Flows higher than 100 fpm are not required for "good" laboratory arrangements and do not improve performance for poor arrangements.

b Operator Effect.

The turbulent air patterns resulting from the passage of makeup air around an operator standing in front of a hood, have tremendous effects on the air flow characteristics. Serious losses of contaminants from the hood can occur unless the low pressure area in front of the operator is minimized via the proper use of makeup air and the assurance of sufficient capture velocity at the face of the hood.

c Air Movement in the Laboratory.

The effect of air movement within the laboratory on the performance of hoods is directly related to hood location and the influence of air supply systems. Hood locations must be away from doors, windows, and pedestrian traffic. Air from these sources can have velocities several orders of magnitude greater than the hood face velocity, creating the potential for dragout or displacement of contaminated air from the hood. Air from outlets, such as ceiling and/or wall diffusers, must either be controlled to assist in the performance of the hood or directed so that the energy is lost before entering the zone of influence. Air from the makeup systems should not exceed 20-25 fpm in the hood face area (measured with the hood exhaust "off"). If these

F GUIDELINES (Continued)

criteria are judged satisfactory, the system then can be considered "good" and the required face velocities of 80-100 fpm are valid.

d Hood Turbulence.

As air enters the hood, it is drawn past equipment and sources of contamination toward the exhaust slots. At airflows greater than needed to provide a good vector and containment, excessive turbulence can cause a "rolling effect" in the hood chamber. This increases the potential for greater mixing of contaminated air and room air at the face of the hood. Under poor laboratory hood arrangements, greater turbulence can result in excessive spill-out of contaminated air into the room. For this reason, it is obvious that substandard hood operations cannot be upgraded merely by increasing air flow.

e Sash Height Performance Marks

A frequently encountered situation with standard hoods is the need to establish a sash position mark which provides a minimally acceptable face velocity. This practice is often necessary because the hood cannot provide the required velocity in the fully open position. It must be noted, however, that this is a questionable practice for a number of reasons.

The sharp edges presented by the bottom of the sash can influence incoming air currents and produce eddies and turbulence which result in outfall of contamination.

Secondly, it is very easy to simply move the mark down as hood performance deteriorates due to some basic, and possibly critical reason that should be investigated and rectified.

The marking of sash positions is, therefore, acceptable only when the following requirements are satisfied:

(1) During the conduct of performance testing for general requirements (see Section IV, Exhibit 1), the bottom edge of the sash will be painted with titanium tetrachloride and turbulence patterns will be observed with the sash in the required position. No reverse flows of air will be allowed along the entire length of the sash.

(2) At no time may the sash mark be posted less than 18 inches up from the work surface of the hood. Any hood that is incapable of satisfying minimum velocity requirements at this height has other deficiencies which must be corrected (see Section f).

F GUIDELINES (Continued)

f Modification and Repair.

Modification and repair of existing fume hood systems, with the purpose of improving performance, should generally follow these steps:

(1) Assess the present operating characteristics of the hood system.

(2) Determine whether repairs are needed due to damage or deterioration.

(3) Determine whether appropriate modifications to the fume hood proper can be made to improve containment characteristics.

(4) Determine whether modifications to the duct system can be appropriately made to lower the static pressure requirement of the exhaust system.

(5) After other methods to improve hood performance have been tried, calculate a new fan speed and horsepower, or change the fan assembly to increase CFM to required level.

4 Design Features of Laboratory Fume Hoods.

a Special Applications.

Specialty units, such as walk-in hoods and biological safety cabinets, present unique design requirements. A complete reference for the operating specifications and certification procedures for biological safety cabinets may be found in the "Laboratory Safety Monograph, A Supplement to the NIH Guidelines for Recombinant DNA Research," January 1979. Copies of this document are available by request through the Safety and Health Program Management Branch (see Page 3 for mailing address).

Special applications requiring extensions of general chemical fume hood design features are feasible in certain instances. They are not exempted from the requirements set forth in this MANUAL.

b New Installations.

Because the laboratory hood is part of an overall system involving the laboratory, the duct system, the fan, and, in certain circumstances, effluent cleaning devices, it is

F GUIDELINES (Continued)

essential that each portion of the system be chosen carefully. Performance criteria must be specified and satisfied. The laboratory hood manufacturer shall provide proof that the unit performs satisfactorily under the conditions required. Materials must meet specified corrosion resistance standards, fans must be rated by the Air Moving and Conditioning Association (AMCA), plumbing fixtures and electrical outlets must meet existing codes, and controls should be externally located whenever possible. Actual specifications and procedures for certifying aerodynamic performance of fume hoods are included in Exhibit 1 of this MANUAL. Some major equipment manufacturers can perform these tests, and the services of independent testng laboratories are also available. The performance of such tests is required when new systems are purchased. When new installations are constructed, careful planning and placement in reference to room air supplies can provide the maximum operator protection with the minimum quantity of air movement.

c Existing Laboratories.

If room conditions and air supplies are not conducive to non-turbulent hood operations, increasing face velocities will not provide satisfactory containment. Room modifications must first be made to provide for air flow into the hood to be less than 20 fpm (with the hood exhaust "off").

Satisfaction of this criterion means that "good" conditions prevail. When "good" conditions are established, 100 fpm shall be used as the design control velocity determined by the means provided in Exhibit 1 and S&E-283 (Exhibit 4) of this MANUAL. To assure continued satisfactory performance, all laboratory hoods should be inspected periodically. The initial survey should be sufficiently extensive to properly rate the overall performance and provide a valid baseline for followup inspections. All hoods should be inspected at least annually. If filters and dampers (or any other special applications) are involved, the inspection should be made at least on a quarterly basis.

5 Hood Exhaust Systems.

Unless specially approved by the Safety and Health Program Management Branch, Administrative Services Division, individual exhaust systems must be provided for each fume hood. Exhaust systems for fume hoods located in the same laboratory space, where each user can see and be aware of the other hood operations, may be combined. Generally, the combining of systems beyond this is strongly discouraged because it increases the

F GUIDELINES (Continued)

potential for many additional problems such as: difficulty in air balancing, loss of control at numerous sites in the event of fan failure, corrosive actions, interference with work of many operators during servicing or performing minor repairs on the system, reduced potential for adding effluent cleaning devices in the future, and the possible undesirable interaction of effluents. It is recognized, however, that certain design situations may not accommodate individual exhaust and will have to be evaluated on a case-by-case basis. A nighttime reduction in exhaust may also be considered during unoccupied hours as a means of conserving energy.

Supply air duct systems within the building can serve multiple labs or hoods if their design incorporates the necessary air volume requirements to assure hazard control ventilation is not interfered with.

Duct material can vary, but long life, corrosion resistance, and accessability for replacement are factors that must be considered. A chart of corrosion resistance characteristics is included as Exhibit 2 of this MANUAL.

Fans must be AMCA rated, and must be installed at the end of each duct system so that all ducts within the building are maintained under negative pressure. Fan discharges should be angular-up into a vertical offset stack, as shown in the ACGIH Industrial Ventilation Manual illustration attached in Appendix III, and the stack should extend well above the roof eddy zone. Generally, stacks extending at least 8-feet above the roof level of one-story buildings and 15-feet above the roof level for multiple-story buildings should be employed for laboratory fume hoods. Discharge should be directed upward at a velocity of <u>at least</u> 2,500 fpm to minimize chances of recirculation.

Asthetic objections may be overcome by architectural consideration for the release of contaminants in the design stages of a structure. Incorporating an exhaust tower or a cluster of exhaust stacks may be made an element of the building. The bunching of exhaust stacks has the added advantage of creating a mass of exhausted gases which is less readily deflected from upward vertical flow by wind gusts. A further, although very costly, alternative is to provide for remote discharge or inlet supply locations.

F GUIDELINES (Continued)

The use of cone-style weather caps is prohibited. Any accumulation of rainwater in the approved stackheads can be minimized by the removal of the plug on the fan scroll. Fresh air inlets for the building supply systems should be displaced as far as possible from the exhaust discharge.

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Exhibits
1 Laboratory Chemical Fume Hood Specifications
2 Corrosion Resistance Chart
3 Stackhead Designs
4 S&E-283

Laboratory Chemical Fume Hood Specifications

I GENERAL DESIGN

a All fume hoods shall be of airfoil design with radiused foil sections at the bottom and sides of the hood opening to insure maximum operating efficiency and minimum eddying of air currents. They shall be the "bypass" type to provide a relatively constant exhaust air volume through the hood regardless of sash position. Horizontal sliding sashes present sharp edges to incoming air currents and produce eddies at all edges. The resultant turbulence can cause outfall of contamination. Horizontal sliding sashes are, therefore, to be avoided.

b Fume hoods shall be designed so that, without modification, at some future date an auxiliary air attachment can be added that will allow the use of up to 70 percent auxiliary air. The auxiliary air attachment shall be mounted forward and above the sash opening, and designed such that all of the auxiliary air shall enter through the hood face when the sash is in the open position, and through the bypass into the hood when the sash is closed. Any design that introduces auxiliary air directly into the interior of the hood, behind the hood face, when the sash is open, will <u>not</u> be acceptable.

II CONSTRUCTION

a Double wall end panels shall be provided for all fume hood superstructures, with the front of the panel at the hood opening radiused, providing a streamlined section and insuring a smooth, even flow of air into the hood. The hood interior and panels shall be flush with the entrance shape to prevent eddy currents and back flow of air. The area between the double wall ends shall be closed to house the sash counter-balance weight and remote control valves as are required.

b An airfoil which presents a streamlined appearance similar to the sides, shall be installed at the bottom of the hood opening. This foil shall be mounted with approximately a 1 inch open space between the foil and the top front edge of the working surface to direct an air stream across the hood work top to prevent any back flow of air at this point. The airfoil shall extend back under the sash, so that the sash closes on top of the foil, and thus does not close the approximate 1-inch opening.

c An automatic air bypass shall be furnished for the hoods at the top of the sash opening. This air bypass shall limit the maximum air velocity through the face of the hood and provide a relatively constant volume of air through the hood (regardless of sash position) when hood exhaust blower is in operation. The hood air bypass shall not be dependent on mechanical or electrical linkage, and shall be completely positive in operation. The bypass shall be located above the hood face opening, just forward of the sash when it is in the raised position. The bypass shall provide an effective sight-tight barrier between the area outside the hood and the hood interior. The bypass shall also provide an effective barrier capable

of controlling transfer of flying debris from inside the hood. The bypass shall control the increase in face velocity as the sash is lowered to attain at least twice but not more than three times design face velocity.

d A removable baffle, with one fixed nonadjustable opening and two adjustable openings - one upper and one lower - shall be furnished at the rear of the hoods. The adjustable baffle openings are to be provided to allow the flow of air through the hood to be adjusted to compensate for types of gases, apparatus, or heat sources used in the hoods.

e Hood exteriors shall be constructed of cold-rolled steel and shall have the component parts either screwed together or fastened by button-hole fasteners to allow the removal of the end panels, front vertical facia pieces, bypass grille, and airfoil to allow replacements or to afford access to the plumbing lines and fixtures. Spacers or reinforcements shall be welded to these main parts. After fabrication of all cold-rolled steel parts, but before final assembly, component parts shall be given an acid, alkali, and solvent resistant finish on both exterior and interior surfaces.

f Hood services shall consist of a cup drain flush with the recessed working surface and plumbing and electrical services as specified. Plumbing services shall consist of remote controlled valves located within the double wall end panels, controlled by extension rods and handles projecting through the vertical airfoils of the hood. Unless otherwise specified, the handles shall be acid resistant, nonmetallic plastic, and shall be furnished with tamper-proof and vandal resistant color coded services indexes. Valves shall be connected to panel flanges and angle serrated hose connectors located on the end panels within the hood. Interior fittings for gases and water shall be integral panel flanges and angle serrated hose connectors of acid resistant plastic, color coded to match the service. Cup drains will be positioned so as to allow direct waterflow from serrated water lines. Vertical facia shall be punched to receive no less than four remote control service fixtures at each side of the hood. Holes not used for specific services shall be provided with removable plug buttons.

g A two-tube fluorescent light fixture (bulbs not included) of the longest practical length (up to 4 feet) shall be provided at the top of the hoods. The light fixture shall be hinged for relamping and shall be shielded from the hood interior by a tempered glass panel sealed into the hood body.

h A vertical sliding sash shall be provided for the hoods unless otherwise specified. Glass used in the sash shall be a minimum of 7/32" thick combination sheet. The sash shall be composed of a minimum of 18 gauge painted steel rolled shape which is mitered, welded, and ground smooth at the corners to provide a complete frame with no visible joints. Glass shall be sealed into the frame with an extruded vinyl channel. The sash shall be counterbalanced with two sash weights suspended one from each end

of the sash by stainless steel cables operating over ball bearing sheaves. The sash frame shall be equipped with plastic guides, which operate in stainless steel sash guides to insure proper operation of the sash and prevent metal-to-metal contact.

i Hood interior lining shall be asbestos cement unless otherwise specified. The end panels, back panel, baffle and top panels shall be not less than 1/4" thick, and shall be screwed together with cleats or steel angles to form a completely rigid assembly to which the exterior cold rolled steel parts can be mounted and to prevent open spaces or joints.

j An exhaust outlet of the size specified, constructed of type 304 stainless steel (unless otherwise specified), extending 2" above the cement asbestos top panel, shall be provided in the top of the hood in the plenum chamber area behind the upper sloping baffle. The rectangular exhaust outlet shall be sized for approximately 1700 fpm air velocity based upon a design hood face velocity of 100 fpm.

k A sash enclosure shall be provided at the top of the hood to receive the vertical sliding sash when it is the in up position. The sash enclosure shall contain two removable panels - one each on the front and rear surfaces for access to the fluorescent lighting fixture for relamping and cleaning. If project specifications require internal wiring to a central junction box, access to the junction box shall be through removable, gasketed panels.

l Removable, flush, cement asbestos panels shall be provided in both interior end panels to provide access to service piping and valves to facilitate installation and maintenance.

m Partial end panels, removable, shall be provided at the exterior ends of hoods to facilitate piping, wiring, and installation.

n Electrical switch(es), receptacle(s), and built in ground fault interrupters, shall be provided per schedules for the project or as specified elsewhere.

o Hood working surface shall be molded epoxy resin (or other material as specified) made in the form of a water-tight pan, not less then 3/8" deep to contain spillage. The raised surface shall be provided all around and the recessed pan area, and it shall be 2" to 4" wide across the front edge.

III DIMENSIONS:

a The superstructure outside dimensions for bench mounted fume hoods shall not exceed 78" in height, 45" in depth, 48", 72", or 96" in length as selected.

b Interior clear working height shall not be less than 44" for the interior of the hood as measured from the work surface.

c The sash opening including space below bottom air foil shall be not less than 28" in height.

IV PERFORMANCE TESTING - GENERAL REQUIREMENTS:

a. The fume hood, when properly installed in a laboratory and connected to an exhaust fan of the proper capacity, shall contain and remove fumes generated within the hood. The face velocity range shall be between 80-100 fpm as selected. The hood shall operate efficiently at any setting within this range. Hood design shall be such that it will exhaust light or heavy gases efficiently when the hood is used for ordinary laboratory work in a room free from cross drafts and without high thermal loads or other special conditions of this nature. No reverse flows of air will be allowed along the sides, top, bottom, or front of the hood. All tests shall be conducted prior to acceptance of newly installed hoods. The owner and/or a designated representative shall view the tests and successful compliance results are contingent upon concurrence by the owner and/or the representative. Failure to meet the performance requirements may be cause for rejection of the supplier.

b The performance test requirements listed in this section are also applicable for the establishment of baseline performance characteristics for comparison with periodic evaluations of existing laboratory chemical fume hoods.

c The following instrumentation, equipment, and supplies shall be on hand for use in the performance tests:

1. Alnor "Velometer" or approved equal, direct reading, with graduations from 0-350 feet/minute.

2. Pitot tube and inclined manometer with graduations no greater than 0.02".

3. One-half minute smoke bombs (3 dozen).

*4 Titanium tetrachloride (4 ounces).

5 Supply of cotton throat swabs.

*Titanium Tetrachloride and its hydrolysis products are highly toxic and iritating. Skin exposure may cause irritation and burns, and even brief contact with the eyes may cause irreversible damage (suppurating conjunctivitis and keratitis, followed by clouding of the cornea).

For this reason, certain precautions should be taken when handling this material. These precautions include the wearing of eye protection and rubber gloves. Care should also be taken to avoid inhalation of aerosolized material.

V PERFORMANCE TEST PROCEDURES:

a "Properly installed" means that the hood shall be installed in an area where there is at least 5 feet clear space in front for observation of the airflow pattern entering the hood. This area shall be without cross drafts or other air currents exceeding 20 fpm that would affect the hood performance in the area in front and around the hood.

b Fume hood face velocities shall be verified as follows: with exhaust fan on, the quantity of air being exhausted shall be determined by measuring the velocity of air entering the hood face and multiplying this velocity by the square feet of hood opening. The hood sash shall be in the fully raised position. The air velocity shall be determined by averaging at least nine velocity readings taken at the hood face. Readings shall be taken in the center of a grid made up of 3 sections across the middle of the hood face and 3 sections each across the bottom and top of the hood face. Readings shall not vary more than $\pm$ 10 fpm from the average face velocity.

c When the selected face velocity has been established, the following tests shall be made:

1 Make a complete traverse of the hood face with a cotton swab dipped in titanium tetrachloride to demonstrate a positive flow of air is maintained into the hood over the entire hood face. No reverse air flows or dead air space shall be permitted.

2 Paint a strip of titanium tetrachloride along each end and across the working surface of the hood, in a line parallel with the hood face and 6" back into the hood to demonstrate that no back flows of air exist at these points. The flow of smoke shall be directly to the rear of the hood without swirling turbulence or reverse flows.

3 A smoke bomb (one-half minute size, as available from E. Vernon Hill Company, San Francisco, California) shall be discharged within the hood area to show the exhaust capability of the hood and its design efficiency. No reverse air flows will be permitted. Place lighted bomb in the hood area and move it to various places, meanwhile checking end panels and working surface to verify that no reverse air flows exist at any point. Lower the sash to closed position to verify that a sufficient air volume is flowing through the hood working area to carry away fumes from a massive fume source. Immediately after the smoke bomb stops discharging smoke, the hood area shall be purged of smoke.

d Lower sash to a point 6 inches above work surface. Velocity, as measured at three points across the reduced face opening, shall be at least two times but less than three times the design face velocity when the sash was fully raised.

e With the sash still at the lowered position, the exhaust air volume (indicated as a function of the average velocity determined in the duct with the pitot tube) shall be essentially the same as when the sash was fully raised. Now lower sash to fully closed position and measure exhaust flow. Total exhaust flow shall be essentially as measured previously with the different sash opening positions.

f Check sash operation by raising and lowering sash. Sash shall glide smoothly and freely, and hold at any height without creeping, assuring proper counterbalance. No metal-to-metal contact shall be allowed between the sash and the sash tract.

VI <u>AUXILIARY FUME HOODS</u>

The design features, construction, and dimensions for the auxiliary air supplied hood are the same as the specifications listed above, but the performance testing includes some additional requirements as listed below:

a The auxiliary air plenum is connected to a bypass hood which has been shown, by the standards listed above, to be functioning in an acceptable manner. No cutting or removal of exhaust duct work shall be permitted.

b Raise the hood sash and verify that the sash does not enter the auxiliary chamber and that there is no appreciable opening or means by which auxiliary air can enter hood either behind the sash or through the bypass until the sash is lowered to the point of bypass opening.

c With the exhaust system off, turn on auxiliary air system and adjust the supply air volume to 70 percent of the exhaust air volume. The supply air volume shall be determined with the pitot tube.

d Measure the air velocity along a line 3" out from the face of the hood and at a height equal to the bottom of the sash when the sash is in a fully raised position. The velocity should not exceed 200 fpm along this line.

e Turn on the exhaust system and operate at an average face velocity of 100 fpm. Maintain supply air operation as outlined in paragraph c. This will provide a 70-30 ratio of auxiliary air to room air being exhausted by the hood.

f Again, traverse the hood face (sash fully raised) with a swab dipped in titanium tetrachloride. The smoke pattern shall show air flowing into the hood and that no back flow exists.

g Paint a strip of titanium tetrachloride along the sides and working surface 6" back from the hood face. All air flow shall be towards rear of hood with no back flow permitted.

h Introduce a 1-minute smoke bomb into the auxiliary air system prior to the point that air enters the plenum and observe the air pattern. Smoke must indicate a smooth uniform air pattern leaving the auxiliary air discharge and smoke must be efficiently entrained and exhausted by the hood when the sash is fully raised.

i Repeat smoke bomb test as in Section V, paragraph 3, but with the sash in fully closed position. Smoke must be efficiently captured by air entering the bypass.

VII PERFORMANCE TEST PROCEDURES: (New Installation of Auxiliary Air Supply Hood)

The following specialized tests are strongly encouraged as part of the certification procedures to be performed by the supplier of a new hood installation. When specified, all tests shall be conducted prior to acceptance and the results are contingent upon concurrence by the owner and/or a representative. Failure to meet these performance requirements may be cause for rejection of the supplier.

Test materials and equipment shall be provided by the manufacturer at his/her own expense.

The materials, instrumentation, and equipment required shall include:

11 - #40 DeVilbiss Nebulizers.
1 - Liter of 5 percent sodium carbonate solution.
50 - cc. of 5-10 percent uranine in 5 percent sodium carbonate solution.
3 - Gelman 47mm filter holders (closed) or equivalent.
1 - Box 47 mm Gelman flass fiber filters type A or equivalent.
3 - Glass probes (for sampling in exhaust duct).
1 - Vaccum pump (Gelman Little Giant model or equivalent).
1 - Source of compressed air.
1 - Mercury manometer (0-25" Hg.).
1 - Flowmeter (Rotameter) for flow rates of 2-10 liters per minute.
3 - Settling flasks (5 liter capacity or larger).
1 - Filter flask (aspirator type).
3 - Limiting orifices for sampling lines (6 liters/min.).
3 - Filter funnels.
1 - Box Whatman #41 filter paper (11 cm. size).
1 - Turner fluorimeter, or equivalent, with proper filters and curvettes.

a Demonstrate that under the 70 percent auxiliary air supply condition, that capture of auxiliary air is at least 95 percent efficient. Use the uranine dye test. Details of the test are described in Section VIII.

b Demonstrate that, under conditions wherein exhaust and supply air volumes are equal, the loss of contaminated air from hood is less than 0.5 percent Tests shall be as prescribed in Section IX.

c Repeat tests in paragraphs a and b but with auxiliary air temperature maintained at 20^{o}F higher than the room air temperature.

VIII URANINE DYE TEST FOR ENTRAINMENT:

a Generation of Fine Uranine Aerosol

1 Place approximately 8 cc of 5 to 10 percent uranine solution into each of two nebulizers.

2 Set up the two nebulizers in parallel; connect air hose from compressed air source and provide access for the mercury manometer in the air line (for pressure reading).

3 Have both nebulizers discharge into the first of the three settling flasks. Arrange for the aerosol to leave the first flask and enter the second flask and then to the third. (Flasks arranged in series). Each flask to be equipped with a tight fitting, two-hole stopper having one long glass tube that extends close to the bottom of the flask and one which is short and extends just into the flask. The aerosol path should be from the nebulizers into each consecutive flask using the long tube and exiting each flask by the short tube.

4 The exit tube of the last settling flask should be connected by use of tubing to the point where the aerosol is to be introduced into the supply air system. This point must be upstream of the auxiliary air chamber and preferably at the inlet to the supply air fan.

5 After checking all joints for tightness, aerosol generation will be started by turning on compressed air and maintaining an 18" to 20" reading on the mercury manometer.

b Air Sampling Procedure

1 Place a three-holed rubber stopper in the filter flask and connect the vacuum pump to the aspirator leg of the flask.

2 Place glass fiber filters in the filter holders (check for tightness).

3 Place limiting orifices on outlet side of the filter holders and connect them to holes in the stopper of the filter flask. (Now all samples are manifolded and will sample simultaneously when pump is turned on).

4 Turn pump on and check airflow through each sampler using the rotameter. All flows must be identical. (Actual flow not critical provided each sampler has same flow rate.)

5 Locate samplers in position for tests as described in sections c and d below.

6 Turn on aerosol generator.

7 Turn on sampling pump.

8 Sample for 5-minutes. Then shut off aerosol generator and sampling pump.

9 Place exactly 50 ml of sodium carbonate solution in the stoppered shaking flasks.

10 Remove filters from the holders using tweezers, and using caution to prevent contamination, place each filter in a numbered shaking flask.

11 Stopper flask and shake vigorously for 3 minutes.

12 Filter a portion of the solution from each flask through separate Whatman #41 filter papers and read fluorescence in the fluorimeter.

13 Make the necessary calculations.

c Check the uniform dispersion of aerosol in supply air. Three simultaneous air samples shall be taken at points across the auxiliary air discharge, and these samples when analyzed must indicate that the uranine aerosol is uniformly distributed in the auxiliary air.

d Check for uniform dispersion of aerosol in exhaust air. Three air samples shall then be taken in the exhaust duct at a point as close to the hood exhaust collar as possible (not more than 4 feet from hood). These discharge samples shall also be taken simultaneously with the sampler inlets located in the same place and at the center of equal areas in the cross sectional area of the exhaust duct. These samples when taken and analyzed must indicate the uniform mixing of auxiliary air and room air.

e Actual test for percent entrainment. When it has been proven that the uranine is properly dispersed throughout the auxiliary air, and that the auxiliary air and room air are thoroughly mixed at the exhaust sampling point, the performance test shall be performed. For this test two samplers, one at the point of discharge of auxiliary air from the supply system and one at the centerline of the hood exhaust duct at the point previously checked shall be taken simultaneously. These samples when analyzed must indicate that at least 95 percent of the auxiliary air supplied is entrained and exhausted. Test to be conducted with sash in fully raised position.

IX HOOD LOSS TEST UNDER IMBALANCE CONDITIONS:

a General: The imbalance test is a simulation of a possible field condition which can be experienced when the exhaust system for an auxiliary air hood exhausts less than the proper amount of air. The reason for such reduced exhaust could be fan belt slippage, fan blade corrosion, and other such commonly encountered problems. To assure adequate and safe performance, the following test requires that when the exhaust air volume has been reduced to equal the supply air volume, the loss does not exceed 0.05 percent of the hood concentration.

b Test Procedure:

1 Set auxiliary air volume (using calibrated flow device) to 70 percent of the exhaust air volume required to provide an average face velocity of 100 fpm.

2 Set auxiliary air temperature so that it is essentially equal to room air temperature.

3 Set exhaust air volume (using calibrated flow device) the same as the auxiliary air volume in (1) above. This provides condition of essentially 100 percent supply.

4 Generate heavy concentration of uranine aerosol within the hood work area by setting up at least 9 of the #40 DeVilbliss Nebulizers filled with 10 percent uranine and each connected to a source of compressed air. Each of the nebulizers should be provided with a goose-neck attachment whch deflects and impinges the aerosol generated onto the bottom of an adjacent beaker. All nebulizers and beakers should be located in a plane 6" back from the hood sash opening, and equally space in that plane.

5 Using the manifolded sampling technique as described in VIIIb, obtain the following three samples simultaneously. Sample No. 1 taken at the centerline of the hood exhaust duct (represents hood concentration). Samples No. 2 and 3 taken 6" in from each side of sash opening, 12" out from plane of sash opening and 6" below level of work surface. The sampling time to be at least sixty minutes in duration.

6 The samples shall then extracted and fluorescence determined as described in Section VIII, paragraph b, Steps 9 through 13.

7 Calculations must indicate that the hood loss under imbalance conditions does not exceed 0.05 percent of the hood concentration.

The chart presented below has been excerpted with the approval of the Sheldons Manufacturing Corporation, 1400 Sheldon Drive, Elgin, Illinois 60120. Additional information on Fume Exhaust Fans for Corrosive Service is available in their Catalog No. 667A.

The use of this information is not intended as an endorsement of any particular company.

CORROSION RESISTANCE CHART

The Corrosion Charts on the following pages have been compiled from the available data provided by the suppliers of the corrosion resistant materials listed, and are intended to serve only as a guide to the comparative usefulness of the listed materials.

NOTE: Sheldons make no specific guarantee against damage by corrosion, erosion or abrasion in the application of any of these materials in any corrosive environment.

No attempt has been made to limit the contents of the Corrosion Chart to corrosive fumes exclusively. Corrosive liquids and solids have also been included for convenient reference.

In some applications, particularly with stainless steel, the dilution of fumes with air may actually accelerate the corrosion rate. In most other applications, the dilution of the corrosive agent with air will produce longer and more satisfactory service than that indicated by the usual tests carried out on immersed specimens.

For more severe conditions than those listed, materials should be tested under actual service environments to ensure suitability of application.

The Corrosion Charts listed have been condensed slightly from more detailed information, which is available on request.

CORROSIVE AGENT	CAST IRON	304 SS	316 SS	MONEL	ALUMINUM	PVC & PLASTISOL	FRP - EPOXY	FRP - POLYESTER	BAKED PHENOLIC	BAKED HERESITE	AIR - DRY HER.	EISENHEISS	*EPOXY PAINT	RUBBER	NEOPRENE	HYPALON
Acetaldehyde					120	U	100				RESULTS SIMILAR TO BAKED HERESITE BUT WILL HAVE MUCH SHORTER LIFE	U				
Acetic Acid — 10%	U	G	E	U	E	140	F	220	160	160		100	U	U	U	U
Acetic Acid — 50%	U	G	E	F	120	140	U	140	160	160		G	U	U	U	U
Acetic Acid Glacial	U	G	G	G	E	U	U	U	160	160		U	U	U	U	U
Acetic Anhydride		G	E	G	E	U	U	U	160	160		U	U			
Acetone	U	E	E	E	E	U	U	80	160	160		U	G	U	U	U
Acetonitrile					E	U		U				U				
Acetophenone					E	U		U					F			
Adipic Acid					E	70			120	120		150			100	100
Alcohol, Allyl					E	U	180		120	120						
Alcohol, Amyl					G	70	180	220	120	120		150				
Alcohol, Benzyl					E	U	180	80	120	120						
Alcohol, Butyl					E	70	180	180	120	120		150		U	U	U
Alcohol, Cetyl						140	180		120	120						
Alcohol, Ethyl	U	E	E		G	70	180	180	120	120		150	E	100	70	80
Alcohol, Furfuryl						U	180		120	120						

*Epoxy paint results based on tests at approximately 90°F.

E — Excellent G — Good F — Fair U — Unsatisfactory Numbers indicate maximum temperature at which coating is satisfactory.

CORROSIVE AGENT	CAST IRON	304 SS	316 SS	MONEL	ALUMINUM	PVC & PLASTISOL	FRP - EPOXY	FRP - POLYESTER	BAKED PHENOLIC	BAKED HERESITE	AIR - DRY HER.	EISENHEISS	*EPOXY PAINT	RUBBER	NEOPRENE	HYPALON
Alcohol, Hexyl					E	140	180		120	120	RESULTS SIMILAR TO BAKED HERESITE BUT WILL HAVE MUCH SHORTER LIFE.					
Alcohol, Isopropyl					E	140	180		120	120		150				
Alcohol, Lauryl						140	180		120	120						
Alcohol, Methyl — 6%	U	E	E		E	140	180	140	120	120		150	E	70	U	U
Alcohol, Nonyl					E	70	180		120	120						
Alcohol, Octyl					E	70	180		120	120						
Alcohol, Propargyl						140	180		120	120						
Alum	U	F	F		G	140		G	120	120		150		200	200	150
Aluminum Acetate		E	E		G	140	180		100	100		150				150
Aluminum Chloride		F	F	—	F	140	180	220	U	U		150		200	150	150
Aluminum Fluoride		F	F	—	U	140	180	U	U	U		150				
Aluminum Hydroxide		E	E	—	—	140	180		U	U		150	E			
Aluminum Nitrate		E	E		G	140	180		100	100		150		150	100	125
Aluminum Oxalate						140	180		100	100		150				
Aluminum Oxychlorate						140			U	U		150				
Aluminum Potass. Sulphate	U	F	F		G	140	180	220	120	120		150				
Aluminum Sulphate	U	F	G	G	F	140	180	220	120	120		150		200	200	150
Ammonia — Dry Gas	U	E	E	—	E	140	180		U	U		150	E			
Ammonia — Liquid	G	E	E		E	U	180	180	U	U		150	E	U	U	U
Ammonium Bicarbonate		E	E		G	140	180	160	100	100		150	E			
Ammonium Bifluoride	U					140	180		100	100		150				
Ammonium Carbonate		E	E	—	E	140	180	80	100	100		150	E			
Ammonium Chloride	U	F	E	E	F	140	180	220	120	120		150		200	150	150
Ammonium Fluoride					100	70	180		100	100						
Ammonium Hydrosulphide					E	140	180		100	100						
Ammonium Hydroxide	E	E	E	F	E	140	180	140	100	100		150	G	U	U	U
Ammonium Metaphosphate					F	140	180		100	100		150				
Ammonium Nitrate	F	E	E	F	E	140	180	220	100	100		150		200	200	125
Ammonium Oxalate		E	E		E	140	180		100	100		150				
Ammonium Persulphate		E	E	U	U	140		180	100	100						
Ammonium Phosphate		E	E	G	F	140	180		120	120		150				
Ammonium Sulphate	U	E	E	G	F	140	180	220	120	120		150		200	200	150
Ammonium Sulphide					G	140	180		120	120		150				
Ammonium Thiocyanate	U				175	140	180		120	120						
Amyl Acetate		E	E		E	U		80	70	70		U	G			
Amyl Chloride		E	E		F	U		60	70	70						
Aniline		E	E		F	U		U	U	U		U				
Aniline Hydrochloride		U	U		U	U	180	180	70	70						
Aniline Sulphate					100	140	180	220	70	70						
Antimony Trichloride		U	U		F	140	180	220								
Arsenic Acid	U	G			G	70								200	100	200
Barium Carbonate		E	E		G	140	180	220				150	E	200	150	200
Barium Chloride	U	G	E		U	140	180	220				150	E	200	150	
Barium Hydroxide					U	140	180	100				150	E	150	200	175
Barium Sulphate		E	E		E	140	180					150	E	200	200	100
Barium Sulphide					U	140	180	140						200		
Beer		E	E	E	E	140	180		100	100		150	F			
Beet Sugar Liquors		E	E	E	E	140	180		100	100		150	G			
Benzene	E	E	E	E	E	U	U	80	120	120		U	F	U	U	U
Benzaldehyde					U	U		U				U	U			
Benzoic Acid		E	E		E	U		220	120	120		150				
Benzoyl Chloride					U	U						U				
Benzyl Acetate					E	U						U				
Bismuth Carbonate					G	140	180		120	120		150	E			
Borax		E	E	E	G	140			120	120		150	E	200	200	200
Boric Acid		E	E	E	E	140		220	150	150		150		200	200	200
Brine	U	E	E		G	140	180	200	120	120		150	G	200	200	200
Bromine	U	U	U		U	U	U	U	U	U		U		U	U	U
Butadiene		E	E	E	F	140	180									
Butane	U				E	140	180		120	120		150		U		
Butanol					E	70	180		100	100		150		U		U
Butyl Acetate		E	E		E	U	F	F	70	70		U	F	U	U	U
Butyl Chloride						U						U		U	U	U
Butyraldehyde					E	U						U		U	U	U
Butyric Acid — 20%		E	E		120	140		220	120	120				U	U	U
Butyric Acid — Conc.		E	E		120	U		220	120	120				U	U	U
Calcium Bisulphite		G	E	U	G	140			70	70		150			U	
Calcium Carbonate		E	E		E	140	180	E	150	150		150	E	200	200	125
Calcium Chlorate		E	E		E	140	180	220				150				
Calcium Chloride	F	F	F	E	G	140	180	220	120	120		150	G	200	175	200
Calcium Hydroxide	F	E	E		F	140	180	220	120	120		150	G	175	200	175
Calcium Hypochlorite	U	F	G	F	F	140	90	220	100	100		150		U	U	U
Calcium Nitrate					E	140	180		100	100		150	G	200	200	200
Calcium Phosphate					U	140	180					150	G			
Calcium Sulphate		E	E		E	140	180	220	150	150		150	G	200	170	175
Carbon Dioxide		E	E	E	E	70	180	220	150	150		150	E	200	200	200
Carbon Disulphide	F	E	E	F	E	U		130						U	U	U
Carbonic Acid		G	E		G	140						150	E	200	200	200
Carbon Monoxide		E	E		E	140		220	150	150		150	E	200	200	200
Carbon Tetrachloride		E	E	E	F	U		B0	120	120		U		U	U	U

*Epoxy paint results based on tests at approximately 90°F.

E — Excellent G — Good F — Fair U — Unsatisfactory Numbers indicate maximum temperature at which coating is satisfactory.

12/21/81

CORROSIVE AGENT	CAST IRON	304 SS	316 SS	MONEL	ALUMINUM	PVC & PLASTISOL	FRP - EPOXY	FRP - POLYESTER	BAKED PHENOLIC	BAKED HERESITE	AIR - DRY HER.	EISENHEISS	*EPOXY PAINT	RUBBER	NEOPRENE	HYPALON
Chloracetic Acid		F	U			70		180			RESULTS SIMILAR TO BAKED HERESITE BUT WILL HAVE MUCH SHORTER LIFE.					
Chlorine — Dry Gas		G	G	E	U	70		220	U	U		150		U	U	U
Chlorine — 10% Dry Gas		U	F	E	U	70		220	U	U		150		U	U	U
Chlorine — Wet Gas		U	F	F	U	U		220	U	U		150		U	U	U
Chlorine Water		F			U	U		160	U	U		150		U	U	U
Chlorine Dioxide						U		220	U	U				U	U	U
Chlorobenzene	F				E	U		80						U	U	U
Chloroform		E	E		U	U		U				U				
Chrome Alum		E				140			120	120						
Chromic Acid	U	G	E	F	F	140	U	140	70	70		U		U	U	U
Citric Acid	U	G	E	G	E	140		220	120	120		150		150	100	100
Copper Chloride		F	U		U	140	180	220	120	120		150				
Copper Cyanide		E	E		U	140	180	220	120	120						
Copper Fluoride					U	140	180		120	120						
Copper Nitrate		E	E		U	140	180		100	100		150		200	150	200
Copper Sulphate	U	E	E	F	U	140	180	220	120	120		150		175	200	200
Creosote		E	E	E	F	U			160	160		150		U	U	U
Cresylic Acids					E	U	U					U		U	U	U
Crotonaldehyde					E	U						U				
Cupric Chloride					U	140	180	E				150				
Cupric Nitrate					U	140	180	E				150		200	150	175
Cupric Sulphate					U	140	180	E				150		175	200	200
Cyclohexanol					E	U	G		120	120		U				
Cyclohexanone						U			120	120		U				
Detergents					G	140	180	160	160	160		150	G			
Dextrin					E	140	180					150				
Dextrose	F				E	140	180					150				
Dichlordifloromethane	U				U	70			120	120		U				
Dichlorethylene					E	U						U				
Dichlorobenzene					176	U	U					U				
Diethylene Glycol					E	140	G	E	100	100		U				
Diethyl Ether					G	U		80				U				
Diethyl Ketone					E	U		80				U				
Dioxane						U			70	70		U				
Disodium Phosphate					U	140	180					150				
Ethane					E	70	E		U	U		150				
Ethanol					G	70	150		U	U		150	E	U	U	U
Ether		E	E		G	U							U	U	U	U
Ethyl Acetate		E	E	G	F	U	F	80	70	70		U	F			
Ethyl Chloride		E	E		G	U										
Ethyl Ether						U			70	70			U			
Ethyl Formate					G	U						U				
Ethyl Sulphate					E	70						U				
Ethylene Chloride		E	E		F	U		U								
Ethylene Dibromide					U	U			160	160						
Ethylene Glycol		E	E	E	E	140	G	220	100	100		U	G	200	U	150
Ethylene Oxide					G	U			70	70		U				
Fatty Acids	U	G	E	G	E	140	F	220				150	F	U	U	U
Ferric Chloride		U	F	U	U	140	180	220	U	U		150		200	85	125
Ferris Nitrate		E	E		U	140	180	220	100	100		150		150		125
Ferric Sulphate		E	F.	F	F	140	180	220	120	120		150		200		125
Ferrous Chloride					U	140		220	120	120		150		200		175
Ferrous Sulphate		E	E		G	140		220	120	120		150		200	85	175
Fluorine		U	U	U	U	U		140								
Fluoboric Acid					U	140		220	150	150				200	100	125
Fluosilicic Acid					U	140		80						200	100	125
Formaldehyde		E	E	E	E	140	80	220	100	100		150		U	U	U
Formic Acid — 25% soln.		G	G	E	U	70		70	70	70		100		U	U	U
Formic Acid — 50% soln.		G	G	E	U	70		70	70	70				U	U	U
Formic Acid — 100% soln.		U	G		E	70		70	70	70				U	U	U
Fruit Pulp	U	E	E	E	F	140		G	100	100		150		U		
Furfural		E	E	E	E	U		160								
Gallic Acid		E	E		E	140						150				
Gasoline	G	E	E	E	E	U	180	220	120	120			E	U	U	U
Glycerine		E	E	E	E	140	G	220	100	100		150	G			
Glycerol		E	E	E	E	140	G	220				150	G			
Glycol					E	140	G					150	G			
Heptane						140	180	220	120	120		150	E	U	U	U
Hexane					E	70	180		120	120		150	E	U	U	U
Hexanol					G	140	180		100	100				U	U	U
Hydrobromic Acid		U	U		E	140		220	U	U		150		200	U	U
Hydrochloric Acid — 10%	U	U	U	F	U	140	180	220	U	U		150	G	200	U	U
Hydrochloric Acid — Conc.	U	U	U	U	U	140	U	160	U	U		150	U	200	U	U
Hydrocyanic Acid	U	E	E	G	E	140		160	100	100						
Hydrofluoric Acid — 4%	U	U	U	F	U	70		180	U	U		U		150	U	U
Hydrofluoric Acid — 40%	U	U	U	U	U	70		150	U	U		U		150	U	U
Hydrofluoric Acid — 60%	U	U	U	U	U	U			U	U		U		U	U	U
Hydrofluoric Acid — Conc.	U	U	U	U	U	U			U	U		U		U	U	U
Hydrogen		E	E	E	E	140						150	E			
Hydrogen Bromide					U	140						150	U			

*Epoxy paint results based on tests at approximately 90°F.

E — Excellent G — Good F — Fair U — Unsatisfactory Numbers indicate maximum temperature at which coating is satisfactory.

CORROSIVE AGENT	CAST IRON	304 SS	316 SS	MONEL	ALUMINUM	PVC & PLASTISOL	FRP - EPOXY	FRP - POLYESTER	BAKED PHENOLIC	BAKED HERESITE	AIR - DRY HER.	EISENHEISS	*EPOXY PAINT	RUBBER	NEOPRENE	HYPALON
Hydrogen Chloride					U	140					RESULTS SIMILAR TO BAKED HERESITE BUT WILL HAVE MUCH SHORTER LIFE.	150	U			
Hydrogen Fluoride		G	G	E	U	140							U			
Hydrogen Peroxide		E	E	G	E	140		160	U	U		150		U	U	U
Hydrogen Sulphide	F	G	E		E	140		180	160	160		150		U	U	
Hydroquinone					E	140			160	160						
Hydrochlorous Acid					U	U		220	U	U		150		U	U	U
Iodine		U	F		U	U								U	U	U
Lactic Acid — 10%	U	G	G	U	G	140		220	120	120		150		150	90	
Lactic Acid — 100%	U	F	G	U	E	U	U	220	120	120		150		150	90	
Lanoline					E	140						U	G			
Lead Acetate		E	E		U	140	180	220	120	120		150				
Lead Arsenate	U				E	140	180					150				
Lead Nitrate	U				U	140	180	180	100	100		150		100	100	150
Lead Tetraethyl					G	140								U	U	U
Magnesium Carbonate		E	E		E	140	180	220				150		200	200	150
Magnesium Chloride		G	E	E	F	140	180	220	120	120		150		200	200	175
Magnesium Hydroxide		E	E	E	U	140	180		140	140		150		200	200	150
Magnesium Nitrate		E	E		G	140	180	180	100	100		150		200	200	150
Magnesium Sulphate		E	E	E	G	140	180	220				150		200	200	175
Maleic Acid					G	70		220						150	100	80
Malic Acid		G	G		G	70			160	160				150	100	80
Manganese Sulphate		E	E			140	180		120	120		150		150	200	175
Mercuric Chloride		U	F	U	U	U		220	100	100		150		200	U	U
Mercuric Cyanide		E	E		U	140						150				
Mercurous Nitrate		E	E		U	140						150				
Mercury		E	E	G	U	140			150	150						
Methanol		E	E		E	70	100		100	100		150	G	150	70	80
Methyl Acetate					E	U						U	G			
Methyl Bromide					F	U						U				
Methyl Chloride		E	E		U	U						U				
Methyl Ethyl Ketone					E	U		80				U	G			
Methyl Sulphate					E	70						U				
Methylated Spirits						70	180					U	E			
Methylene Chloride		E			G	U						U				
Mineral Oils					E	140	180		160	160		U	E			
Mixed Acids — All Concs.		140	140		U	U						U				
Naphtha	U	E	E		E	140	180	220	120	120		150	E	U	U	U
Naphthalene	U	E	E		F	U		220	120	120		150		U	U	U
Nickel Chloride		G	G	G	U	140	180	220	120	120		150		200	200	175
Nickel Nitrate		E	E		U	140	180	220	100	100		150		200	100	150
Nickel Sulphate		E	E	E	U	140	180	220	120	120		150		200	200	175
Nitric Acid — 5% soln.	U	E	E	U	G	70	80	160	U	U		150	U	150	U	U
Nitric Acid — 25% soln.	U	E	E	U	E	70	U	80	U	U		150	U	U	U	U
Nitric Acid — 50% soln.	U	E	E	U	E	70	U		U	U		150	U	U	U	U
Nitric Acid — 70% soln.	U	G	G	U	G	U	U		U	U		150	U	U	U	U
Nitric Acid — 95% soln.	U	G	G	U	F	U	U		U	U			U	U	U	U
Nitrobenzene					E	U		U				U		U	U	U
Nitrous Fumes		E	E		E	U			U	U				U	U	U
Octane						70	180		120	120		E		U	U	U
Octanol					E	70	180					F	E			
Oleic Acid	U	G	E	E	F	140		220	120	120		150				
Oxalic Acid		G	E	F	G	140		220	120	120		150	U	150	200	175
Palmitic Acid		E	E		E	140						150				
Paraffin, Kerosene		E	E		E	140	180	220				150	E	U	U	U
Pentane					E	70	180		120	120		150	E	U	U	U
Perchloric Acid — 10%		G	E	E	F	70		160						U	U	U
Perchlorethylene	U				F			80				U				
Petrol/Benzene Mix.					G	U						U	F	U	U	U
Phenol	U	E	E		120	70		140				U		U	U	U
Phenylcarbinol					E	U								U	U	U
Phosphates					U	140	180					150				
Phosphoric Acid — All solns.	U	U	G	G	U	140		220	160	160		150		U	U	U
Phthalic Anhydride					E	140		220	120	120		150				
Pickling Soln.					F	—		180					U			
Picric Acid (in Alchohol)		E	E	U	E	140		160								
Plating Soln. — Except Conc. Caustic					U	140		180						U	U	U
Polyglycol Ethers						U								U	U	U
Potassium Acid Sulphate					G	140			120	120		150		200	170	175
Potassium Bicarbonate		E	E		E	140	180	180	120	120		150	G	200	200	200
Potassium Bichromate		E	E		E	140			120	120		150		U	150	150
Potassium Bisulphite					E	140			70	70		150		200	U	U
Potassium Borate						140	180		120	120		150				
Potassium Bromate						140			120	120		150				
Potassium Bromide		F	G		F	140	180	140	120	120		150				
Potassium Carbonate		E	E		U	140	180	80	120	120		150	G	200	200	200
Potassium Chlorate		E	E		E	140			120	120		150				
Potassium Chloride		G	G	E	E	140	180	220	120	120		150	G	200	200	200
Potassium Chromate					E	140			120	120		150		U	150	175
Potassium Cyanide		E	E		U	140	180	180	120	120				200	150	150
Potassium Dichromate		E	E		E	140		220	120	120		150		U	150	175

*Epoxy paint results based on tests at approximately 90°F.

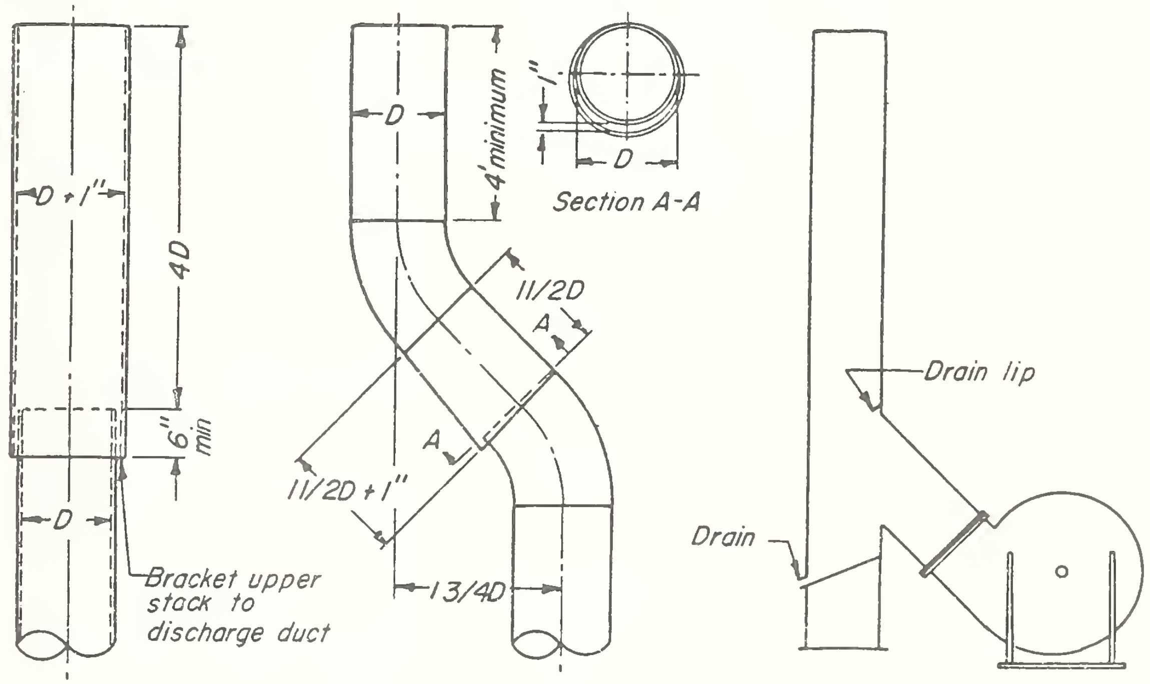
E — Excellent G — Good F — Fair U — Unsatisfactory Numbers indicate maximum temperature at which coating is satisfactory.

CORROSIVE AGENT	CAST IRON	304 SS	316 SS	MONEL	ALUMINUM	PVC & PLASTISOL	FRP - EPOXY	FRP - POLYESTER	BAKED PHENOLIC	BAKED HERESITE	AIR - DRY HER.	EISENHEISS	*EPOXY PAINT	RUBBER	NEOPRENE	HYPALON
Potassium Ferrocyanide		E	E		E	140		220			RESULTS SIMILAR TO BAKED HERESITE BUT WILL HAVE MUCH SHORTER LIFE.	150		100	U	80
Potassium Fluoride					G	140	180					150				
Potassium Hydroxide — 10%		E	E	E	U	140	180	160	120	120		150	G	150	220	200
Potassium Hydroxide — conc.		E	E		U	140	180	80	U	U		150	G	150	220	200
Potassium Hypochlorite		70	70		F	140	F		100	100		150		100	U	U
Potassium Nitrate		E	E		E	140	180	220	120	120		150	G	180	200	200
Potassium Permanganate		E	E		E	140		220	U	U		150		150	U	U
Potassium Persulphate					U	140		220	120	120		150				
Potassium Phosphate					U	140	180		120	120		105		200	200	200
Potassium Sulphate		E	E	E	E	140	180	220	120	120		105		200	200	200
Potassium Sulphide		E	E		U	140	180		100	100		150				
Potassium Thiosulphate						140			120	120		150		200	70	
Propane		E	E	E	E	70	180					150	G	U	G	U
Propylene Dichloride					U	U			110	110						
Propylene Glycol					E	140	G		100	100			G			
Salicylic Acid					G	140			120	120		150				
Sea Water	U			E	E	140	180	G	120	120		150	G	U	E	E
Silver Cyanide		E	E		U	140		180				150				
Silver Nitrate		E	E		U	140		220				150				
Sodium Acetate		E	E		E	140	180	220	120	120		150		175	100	125
Sodium Acid Sulphate					G	140			120	120		150		200	170	175
Sodium Aluminate					U	140	180		100	100		150				
Sodium Benzoate					E	70		180				150				
Sodium Bicarbonate		E	E	E	E	140	180	180	120	120		150	G	200	200	200
Sodium Bisulphate		E	E	E	G	140	180	220	100	100		150		200	170	175
Sodium Bisulphite		E	E		E	140		220	70	70		150		200	U	U
Sodium Borate		E	E		E	140	180		120	120		150				
Sodium Bromide	U	G	G		G	140	180		120	120		150				
Sodium Carbonate	E	E	E	E	G	140	180	140	120	120		150	G	200	200	200
Sodium Chlorate		E	E		G	140			120	120		150		200	200	200
Sodium Chloride	U	G	E	E	G	140	180	220	120	120		150	G	200	200	200
Sodium Cyanide	F	G	E	E	U	140		220	120	120		150		200	150	150
Sodium Ferricyanide					U	140		220				150		100	U	80
Sodium Fluoride					E	140	180					150				
Sodium Hydroxide — 10% soln.	U	E	E	E	U	140	180	180	100	100		150	G	200	220	200
Sodium Hydroxide — 25% soln.	U	E	E	E		140	180	80				150	G	200	220	200
Sodium Hydroxide conc.	U	G	G		U	140	180						G	150	220	200
Sodium Hydrochlorite	U	F	G	F	G	140		180	100	100		150		100		
Sodium Metaphosphate		E	E	E	E	140	180					150				
Sodium Nitrate		E	E	E	E	140.	180	220	120	120		150		180	200	200
Sodium Nitrite		E	E		E	140		220	120	120		150			150	175
Sodium Perborate		E	E	E	E	140						150				
Sodium Peroxide		E	E	E	F	140						150				
Sodium Phosphate	E	E	E	E	U	140	180		120	120		150		200	200	200
Sodium Silicate		E	E	E	G	140	180	220	120	120		150		200	200	
Sodium Sulphate		E	E	E	E	140	180	220	120	120		150		200	200	200
Sodium Sulphide		E	G	F	U	140						150				
Sodium Sulphite		E	E		G	140		220	120	120		150		200	150	150
Sodium Thiosulphate		E	E	G	E	140			120	120		150		200	200	200
Stannic Chloride	U	U	U		U	140		220	120	120		150		200	150	125
Stannous Chloride		G	G		U	140		220	120	120		150		200	100	150
Stearic Acid		E	E	E	G	140		220	120	120		150				
Sulphur — Colloidal		E	E	F	E	140	180									
Sulphur Dioxide — Dry		E	E	E	E	140	180	220	80	80		150		150	U	U
Sulphur Dioxide — Moist		G	E	U	G	70		220	70	70		150		150	U	U
Sulphur Dioxide — Liquid				U	G	U			70	70		150		150	U	U
Sulphuric Acid — To 80% soln.	U	U	U	U	G	140		160	U	U		150		U	U	U
Sulphuric Acid — 95% soln.	F	F	G	U	E	70		U	U	U				U	U	U
Sulphuric Acid — Fuming		G	G	U	E	U			U	U				U	U	U
Sulphurous Acid — 30% soln.	U	F	G	U	G	140		180	U	U		150		150	U	U
Sulphur Trioxide					E	140		220				150				
Tannic Acid	U	E	E		E	140		220	140	140		150		150	200	
Tartaric Acid		G	E	G	E	140		220	120	120		150		200	100	125
Tolvene		E	E	E	E	U	120	80	120	120		U	G			
Trichloroethylene		E	E	E	E	U			160	160		U				
Trichlorobenzene					E	U						U				
Tricresyl Phosphate					E	U						U				
Triethanolamine					G	140			100	100		U				
Triethylene Glycol						140	150						G			
Trimethylpropane						70	180					F	G			
Trisodium Phosphate					U	140	180	220	120	120		150		200	200	200
Turpentine		E	E	E	E	140	180		120	120		F	G	U	U	U
Urea					E	140	180		100	100		150				
Wines & Spirits	U	E	E	E	G	70	180		100	100		150		G	G	U
Xylene		E	E	E	E	U	100	80	120	120		U	G	U	U	U
Xylenol					E	U						U	G	U	U	U
Zinc Carbonate						140	180					150	G			
Zinc Chloride		U	G	F	U	140	180	220	100	100		150		200	150	150
Zinc Oxide					G	140	180					150				
Zinc Sulphate	U	E	E	F	E	140	180	220	120	120		150		200	150	175

*Epoxy paint results based on tests at approximately 90°F.

E — Excellent G — Good F — Fair U — Unsatisfactory Numbers indicate maximum temperature at which coating is satisfactory.

STACKHEAD DESIGNS



VERTICAL DISCHARGE(87)(116) — No loss

OFFSET ELBOWS(106) — Calculate losses due to elbows

OFFSET STACK(106)

1. Rain protection characteristics of these caps are superior to a deflecting cap located 0.75D from top of stack.

2. The length of upper stack is related to rain protection. Excessive additional distance may cause "Blowout" of effluent at the gap between upper and lower sections.(86)

LABORATORY CHEMICAL FUME HOOD INSPECTION

DATE OF PREVIOUS INSPECTION | DATE

THIS INSPECTION PERFORMED BY *(Name)*

LOCATION OF HOOD

TYPE OF HOOD

☐ Standard ☐ Auxiliary Air supply ☐ Other *(Specify)*

GENERAL TOXICITY RATING OF MATERIAL USED IN HOOD

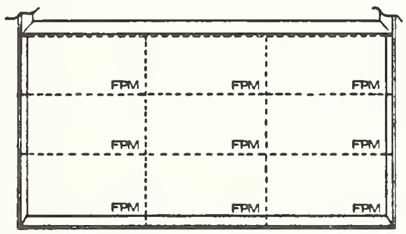
☐ Low *(STEL ≥ 1,000 PPM)* ☐ Medium ☐ High *(STEL ≤ 10 PPM)*

CROSS SECTIONAL AREA AT FACE

Height: ________ feet x Width: ________ feet = ________ feet ^{2}.

AIR VELOCITY READINGS

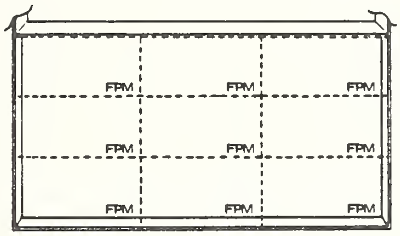
(Readings are to be taken in the center at each of the prescribed frontal locations.)



Exhaust **off**, sash fully **raised**.
(Exhaust flow value equal to zero CFPM.)

$$\frac{FPM_1 + FPM_2 + FPM_3 + \ldots FPM_9}{9} = \text{FPM average.}$$

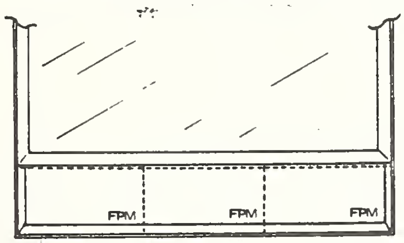
Average value ________ FPM.
(Value should not exceed 20 FPM.)



Exhaust **on**, sash fully **raised**.
(Readings may not vary more than ± 10 FPM from average value.)

Average value ________ FPM.
(Value should be 80 - 100 FPM.)

Exhaust flow value ______ CFPM.



Exhaust **on**, sash **6 inches above work surface**.
(Readings shall be at least 2 but not more than 3 times the face velocity when sash was fully raised.)

Average value ________ FPM.

Exhaust flow value ______ CFPM

EXHAUST READING WITH SASH CLOSED

Should be essentially the same readings as those obtained with sash fully opened and sash 6 inches above the work surface.

Exhaust flow value ______ CFPM.

TITANIUM TETRACHLORIDE INDICATION OF FLOW PATTERNS AT HOOD FACE.

☐ Satisfactory flow patterns evident.
☐ Unsatisfactory *(describe)*: ____________________

ONE-MINUTE SMOKE BOMB DISCHARGE

☐ Effective smoke removal with sash fully raised.
☐ Effective smoke removal with sash 6 inches above work surface.
☐ Effective smoke removal with sash closed.

☐ If unsatisfactory, describe: ____________________

APPROVAL

☐ This hood is found to be acceptable for use with materials of the general toxicity rating as specified above.
☐ This hood has been found **UNACCEPTABLE**.

SIGNATURE | DATE

Form S&E-283 (8/81) USDA-S&E

LABORATORY CHEMICAL FUME HOOD INSPECTION

DATE OF PREVIOUS INSPECTION

DATE

THIS INSPECTION PERFORMED BY *(Name)*

LOCATION OF HOOD

TYPE OF HOOD

☐ Standard ☐ Auxiliary Air supply ☐ Other *(Specify)*

GENERAL TOXICITY RATING OF MATERIAL USED IN HOOD

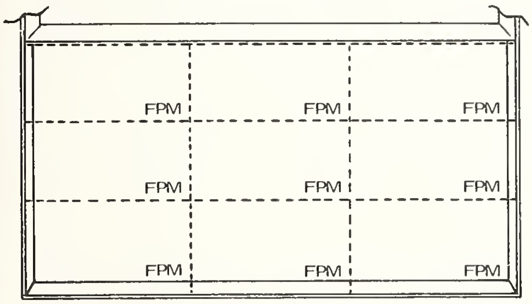
☐ Low *(STEL ≥ 1,000 PPM)* ☐ Medium ☐ High *(STEL ≤ 10 PPM)*

CROSS SECTIONAL AREA AT FACE

Height: ________ feet x Width: ________ feet = ________ feet ^{2}.

AIR VELOCITY READINGS

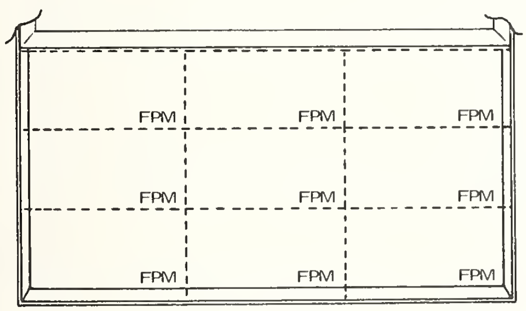
(Readings are to be taken in the center at **each** *of the prescribed frontal locations.)*



Exhaust **off**, sash fully **raised**.
(Exhaust flow value equal to zero CFPM.)

$$\frac{FPM_1 + FPM_2 + FPM_3 + \ldots\ldots FPM_9}{9} = \text{FPM average.}$$

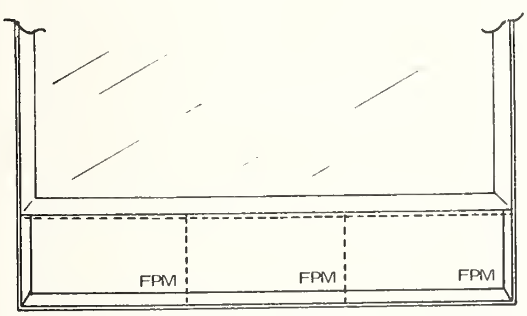
Average value ____________ FPM.
(Value should not exceed 20 FPM.)



Exhaust **on**, sash fully **raised**.
(Readings may not vary more than ± 10 FPM from average value.)

Average value ____________ FPM.
(Value should be 80 - 100 FPM.)

Exhaust flow value ________ CFPM.



Exhaust **on**, sash **6 inches above work surface.**
(Readings shall be at least 2 but not more than 3 times the face velocity when sash was fully raised.)

Average value ____________ FPM.

Exhaust flow value ________ CFPM

EXHAUST READING WITH SASH CLOSED

Should be essentially the same readings as those obtained with sash fully opened **and** sash 6 inches above the work surface.

Exhaust flow value ________ CFPM.

TITANIUM TETRACHLORIDE INDICATION OF FLOW PATTERNS AT HOOD FACE.

☐ Satisfactory flow patterns evident.

☐ Unsatisfactory *(describe)*:

ONE-MINUTE SMOKE BOMB DISCHARGE

☐ Effective smoke removal with sash fully raised.

☐ Effective smoke removal with sash 6 inches above work surface.

☐ Effective smoke removal with sash closed.

☐ If unsatisfactory, describe: ____________________

APPROVAL

☐ This hood is found to be acceptable for use with materials of the general toxicity rating as specified above.

☐ This hood has been found **UNACCEPTABLE**.

SIGNATURE

DATE

Form S&E-283 (8/81)

USDA-S&E